

Just in Time Assurance

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Weinberg's Second Law

**"If builders built buildings the way programmers wrote programs,
then the first woodpecker that came along would destroy
civilization."**

- Anyone can get a system certified with enough time, money, threats, and waivers
- It takes skill to design a system that is practical and affordable to certify
- It takes a virtuoso to design a system that is practical and affordable to recertify given unpredictable but inevitable obsolescence events
- ***This presentation discusses how practical and affordable recertification can become the norm instead of the rare exception***



What Does Just in Time Mean?

- Manufacturing:
 - Parts arrive only when needed because inventory is waste.
 - Requirement: Quick notice of stock depletion
- Assurance:
 - Only modified components are reevaluated because total system reevaluation is waste.
 - Requirement: **NEAT** system architecture



What is NEATness?

- **N**on-bypassable:
 - The infrastructure guarantees critical reference monitors in information flow paths can't be circumvented
- **E**valuatable:
 - Each critical reference monitor is small and simple enough to enable unambiguous specification and rigorous evaluation
- **A**lways Invoked:
 - Critical reference monitors enforce their *local* security policy for every object they manage
- **T**amper Proof:
 - The infrastructure guarantees subversive agents can't modify any critical reference monitor's security functions or data.



Local Security Policy Enforcement

“Critical reference monitors enforce their *local* security policy for every object they manage”

- Why the *local*?
 - A reference monitor should not know anything about any other part of the system
 - Reference monitor scope is constrained to the objects it manages
- A local reference monitor can be maintained, updated, and replaced with minimal effect on the rest of the system
 - A firewall or controlled interface in an enterprise network should not have knowledge about anything other than the policy it must enforce
 - A reference monitor in a real-time embedded system should not have knowledge about the specific platform on which it has been deployed
- A system can be certified, deployed, updated, recertified, and redeployed with reevaluation required only for the new components
- **RESULT:** the cost spiral caused by obsolescence events can be controlled



NEATness Verification

- Provide assurance that the infrastructure has security properties that protect reference monitors from ***TIME*** events
- ***TIME*:**
 - ***Type*** safety violation
 - ***Infiltration*** violation
 - ***Mediation*** violation
 - ***Exfiltration*** violation



TIME: Type Safety Violation

- When an object of one type is expected, a different type is delivered
- Consequences:
 - Buffer overflow
 - Address redirection
 - Unauthorized configuration modification
 - Activation of unintended code
 - Mission software turned into malware
 - Virus contagion
 - Root kit injection
 - Access control bypass



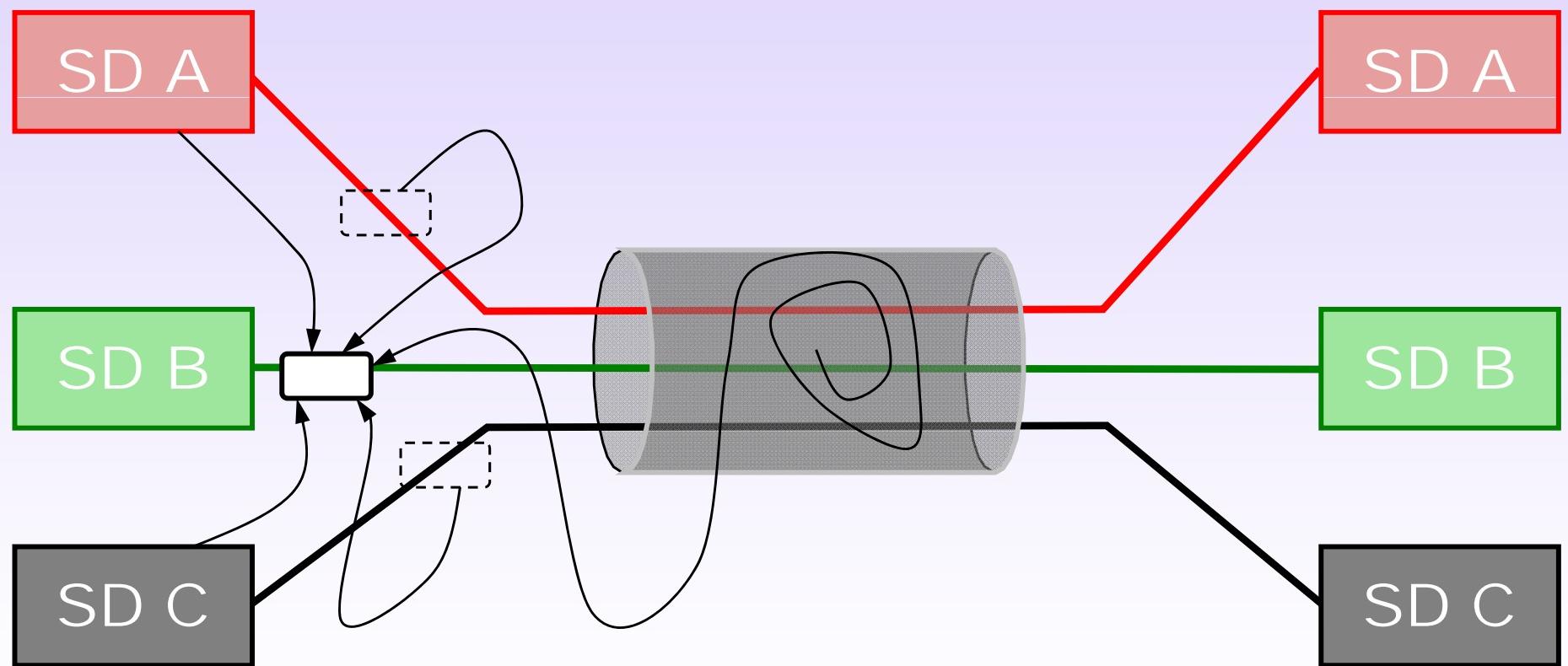
TIME: Infiltration

An unauthorized party may insert data into a channel, compromising integrity

- Party 1: An entity not authorized to send content on certain channels
- Party 2: Software, hardware, or systems that can attempt modification of traffic on certain channels but are not authorized to send content on those channels



Infiltration

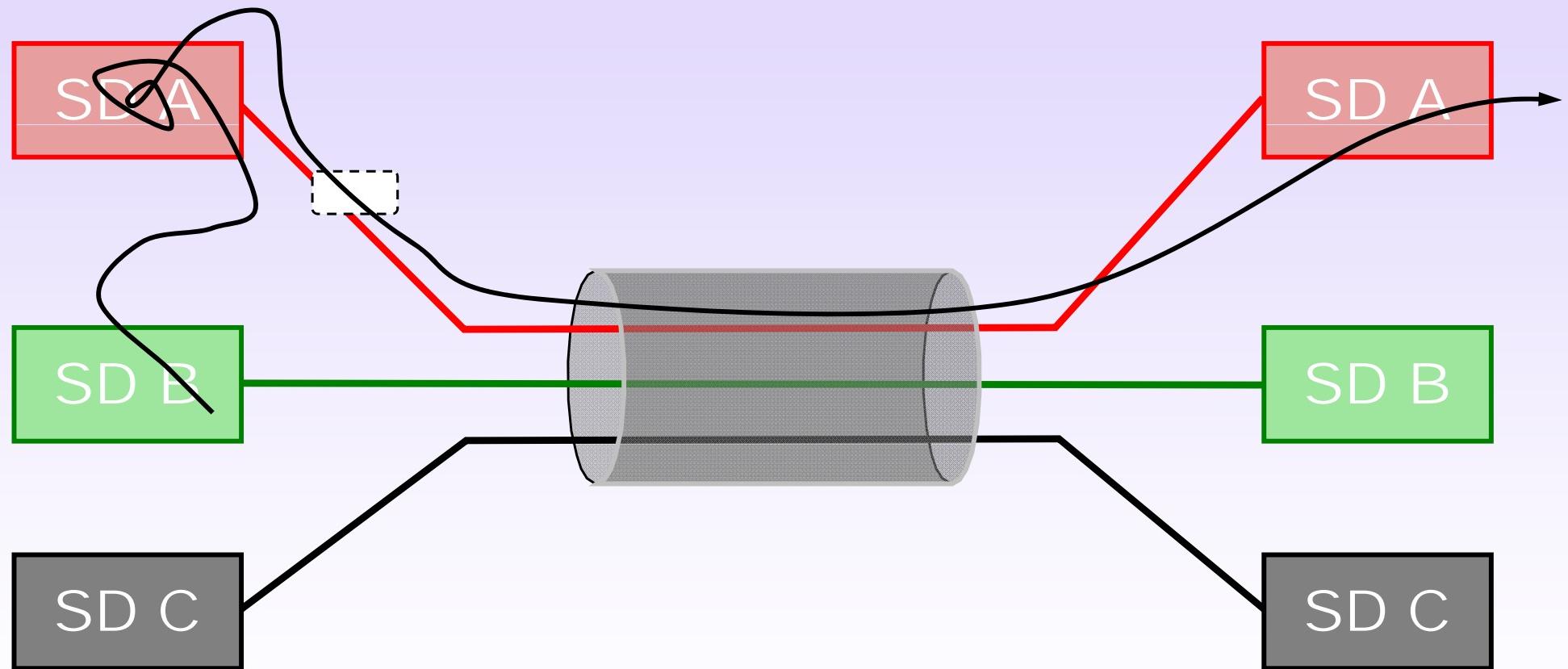


TIME: Mediation

- An unauthorized party may initiate or cause an information flow, compromising control
- Party 3: An entity that is not authorized to send content or cause content to be sent on certain channels



Mediation

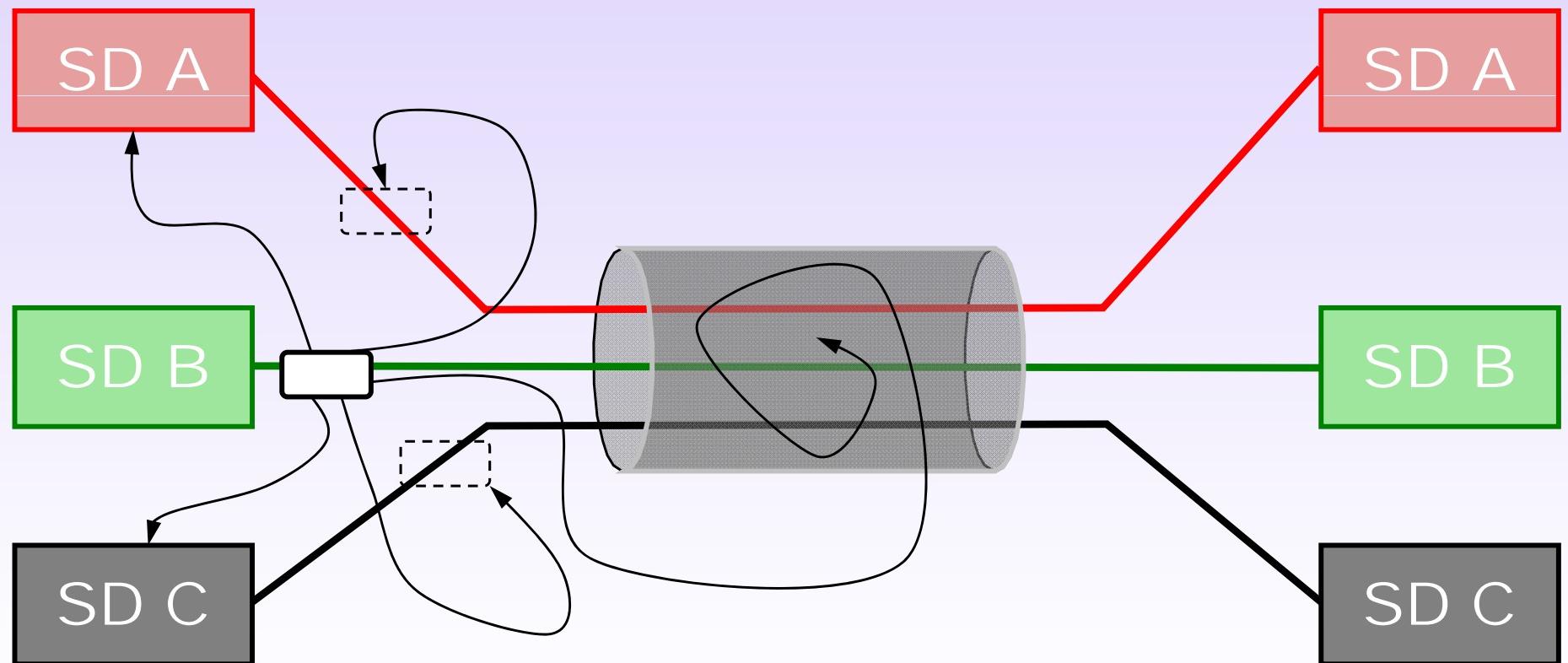


TIME: Exfiltration

- An unauthorized party may perceive data in a channel, compromising confidentiality
- Party 4: An entity that is not authorized to receive content on certain channels
- Party 5: Software, hardware, or systems that can “see” all traffic of certain channels but are not authorized to receive the content of those channels



Exfiltration



Mitigating *TIME* Threats to *NEAT*ness

- Trustworthy separation enables security policy enforcement to be decomposed along structural lines
- Separation with respect to:
 - Space: Private data remains private
 - Time: Periods processing
 - Information Flow:
 - Only when initiated by authorized subjects,
 - Only delivered to authorized recipients
 - Sender authenticated to receiver



Benefits of Separation

- Specified interfaces are the only way that information may flow
 - **T:** Inappropriate data types can't be presented to an interface
 - **I:** There can be no infiltration (information pull violation)
 - **M:** There can be no mediation (control violation)
 - **E:** There can be no exfiltration (information push violation)
- Security Policy enforcement behaviors can be localized to each component reference monitor.
- Security policy architecture can then be decomposed as boxes and arrows



Boxes and Arrows Decomposition

- Boxes encapsulate objects
 - Access only local data and incoming communications
- Arrows are channels for information flow among boxes
 - Strictly unidirectional
 - Absence of arrows is just as crucial as their presence
- Draw enough boxes so that the ones that must be trustworthy are small and simple
 - Assume, for now, that boxes and arrows are “free”



Least Privilege Boxes

- A module trusted to enforce a system security policy in one layer can be untrusted in a different layer
- When a vulnerability in a reference monitor is found, it can be fixed without having to change anything else.
 - If we don't change anything else, we don't have to recertify the "anything else."
- The architecture has done its job.



Security Policy Decomposition Benefits

- Each least privilege security policy enforcement box is smaller, simpler, and more readily evaluable
- Original security policy composition arguments remain unchanged despite obsolescence events
- Systems become more maintainable, adaptable, and extensible
- New threats from smarter and more experienced adversaries can be mitigated without redesigning the entire system



Compositional Assurance

- Compositional assurance is the path towards the goal of JIT Assurance
 - Construct individual assurance case for each trusted component
 - Provide argument that local policies combine to enforce the overall system policy
- ***Composability enables JIT Assurance***
 - A component can be patched, upgraded, refreshed, or replaced without affecting any other “parts”
 - Total system assurance is maintained at reasonable cost despite obsolescence events



Survivability

✓ CONFIDENTIALITY

- Critical Data **PROTECTED**

✓ INTEGRITY

- Free of Unauthorized Manipulation

✓ AUTHENTICATION

- Identity Confirmed

✓ AUTHORIZATION

- Privilege Confirmed

- Mutual Suspicion

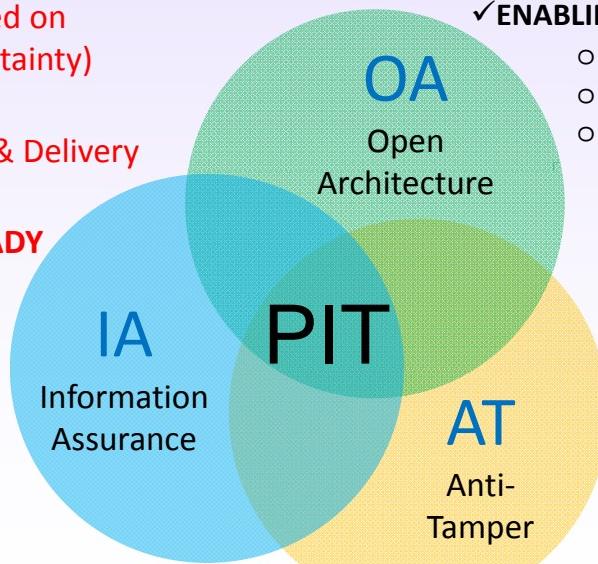
(Reduced access based on authentication uncertainty)

✓ NON-REPUDIATION

- Proof of Data Origin & Delivery

✓ AVAILABILITY

- Critical functions **READY**



✓ DESIGNATE KEY INFORMATION EXCHANGES

- Standardize similar areas at Enterprise level across Primes
- Blue force tracking, strike, mission planning , weather, ...

✓ MODULARITY & VISIBILITY

- Enable affordable, safe and secure Technology Refreshes
- Enable low cost rapid Technology Insertion
- Enable recovery and adaptation against Zero-day Defects

✓ RE-USEABLE COMPONENTS

- Commercial based standards (POSIX, Open GL) - unmodified
- Published standards (IEEE 1394, 802.11) - unmodified
- Established proprietary standards (USB, Blue Ray) - unmodified

✓ INTEROPERABILITY & SECURITY (CJCSI 6212.01E)

- Global Network Information Enterprise Architecture
- Support for Distributed degree of trust systems

✓ ENABLING ENVIRONMENTS

- Infrastructure and Enterprise API's Separable
- Decouple data producers and consumers (cloud computing)
- Register data grams and data streams within metadata registry

✓ DETERRENCE

- Undesirable Consequences
- Strength of Mechanism

✓ PREVENTION

- Defense in Depth
- Obfuscation

✓ DETECTION

- Visual, Alarm, Loss of Function, Attestation
- Monitoring

✓ RESPONSE

- Destruction, Disabling, Zeroization
- Adaption



System Life Total Cost of Ownership

Implementation

Certification / Accreditation

Deployment

Operations, Maintenance, and Administration

Technology Refresh

Growing Attack Surface over time

Obsolescence Events



Summary

- Separation enables JIT Assurance
- Networks of separated modules with proscribed frameworks to integrate them
- Trust of separation infrastructure to be verified.
 - Software implemented separation
 - Deployment of virtualization implementing isolation and redundancy
 - Requires validation of underlying hardware separation mechanisms (i.e., MMU, TPM, VT-d, etc.)
- Verification can be reused during all remaining steps in the system life cycle

